Space Weather Technical Forecast

Issued on Wednesday, 22 February 2023 at 01:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: M-class flares (R1-R2; Minor-Moderate radio blackouts) Likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate in the past 24 hours, as recorded at GOES16, with two M-class flares observed with one at 21/1123UTC reaching M4.7 and the second at 21/2017UTC reaching M5.1 both originating from AR3234. This is the most notable region on the disc and is classified Eki/Beta-Gamma-Delta, with rapid areal growth in its trailing spots. Six other numbered active regions are on the solar disc at present. Most of these are either stable and unipolar or else in decay, including the X2.2-producing AR3229 (on 17 February), which has seen its delta spot fade as well as an overall areal decline.
A few Coronal Mass Ejections (CMEs) were visible in available coronagraph imagery for the period. A front-sided northwestern CME visible on Lasco C2 heading largely northwest was tentatively traced back to activity high in the corona in AIA171 (near the edge of the field of view) around the turn of the UTC day. Any effect from this is likely to be minor and related to the shock only - later this working week. Also observed was a large, fast southeastern far-sided CME seen on STEREO A COR2 with no effect at Earth. Currently no significant Earth-directed CMEs are forecast, although glancing impacts may occur on days 2 and 4 (Thursday and Saturday).

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR at L1, were indicative of ongoing CME influence from the 17 February X2.2-tied event, which arrived at Earth 20/1045UTC to muted effect. The low energy proton increases observed at ACE EPAM LEMS have shown a reduction in energies. The solar wind has been mostly Slightly Elevated, with a few spells to slow-ambient levels noted. The solar wind density has been at mostly average levels with a peak reaching 14ppcc at 21/1557UTC. The IMF has been at Weak to Moderate levels reaching 15nT at 21/0959UTC. The north-south component, Bz, was erratic in nature about being neutrally-orientated, and transitioned to become mainly anti-aligned with the Earth's field for a time in the morning with limits of +9 and -13nT (Weak to Moderate). The phi angle was mainly away from the Sun (positive), with some deviation observed. The net result of the above solar wind measures has been provisionally Quiet to Unsettled despite the CME, with a peak of Kp '3+' seen in the 00-03UTC and 09-12UTC intervals.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2MeV) at GOES16 ranged between Moderate and Normal Background levels, with a diurnal peak of 428pfu at 21/1730UTC. The associated 24-hour electron fluence has been well below the Active (1e8 integrated pfu) threshold, with a step-wise rising tendency to reach 4.01e6 integrated pfu at 22/0001UTC.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate solar activity is forecast this guidance period, with the presence of both the X2.2-producing AR3229 and now a new potent and growing region AR3234 in the northeast. Both of these dominant groups should be present throughout the four days.

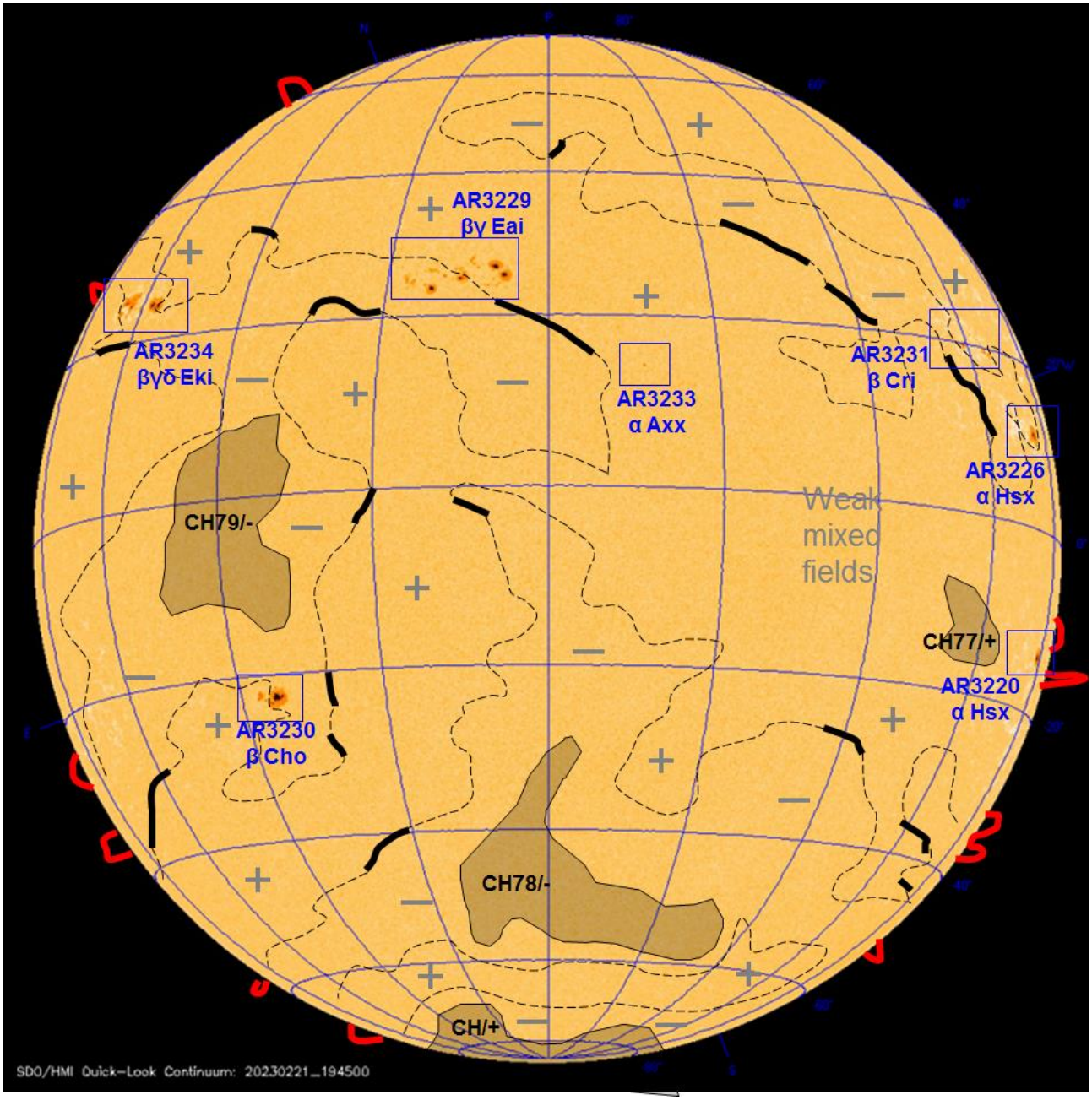
Solar Wind / Geomagnetic Activity: There is one low confidence CME in the forecast - that which left the southwest quadrant on 19 February, although any influence should be from the shock only and even this is low confidence, passing 1AU later Wednesday 22 or into Thursday 23 February (UTC). Another glancing blow is possible on Day 4 (Saturday 25 February 2023). The above excepted, Earth will probably experience slightly elevated solar winds before entering a High Speed Stream (HSS) related to CH77's during day one, Wednesday 22 February, and this gives a peak Slight Chance of G1 for the four-day period, reducing with time to largely Quiet conditions by the end of the current UTC week (with moderate confidence given the possibilities of CME shocks).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at Background levels, but with a slowly increasing Slight Chance of rising towards the S1 level, perhaps exceeding it, should any suitable larger flares occur. High energy (greater than 2 MeV) electron flux may increase later in the forecast period in response to the fast wind enhancement, however this is low confidence. The associated 24-hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 2000UTC, 21 February 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Met Office Space Weather Technical Forecast

Geomagnetic Storms:

There is one low confidence CME in the forecast - that which left the southwest quadrant as a prominence eruption on 19 February, although any influence should be from the shock only and even this is low confidence, passing 1AU later Wednesday 22 or into Thursday 23 February (UTC). A second glancing blow from a CME is possible on day 4 (Saturday 25 February 2023), from a CME that left the sun from the northwest on 21 February, but most of this should pass over Earth. The above excepted, Earth should see a slight elevated regime transition to a HSS one related to CH77's during the UTC morning of day one, Wednesday 22 February. STEREO A PLASTIC measurements suggest a HSS may have arrived as of 21/0700UTC, although there are data gaps and CME pollution to contend with that lower confidence. Should this be the cause, CH77 can be expected to arrive around UTC dawn on day one, Wednesday 22 February to give a peak Slight Chance of G1 for the four-day period. This should then reduce with time to largely Quiet conditions by the end of the current UTC week (with moderate confidence given the possibilities of CME shocks).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	10	1	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

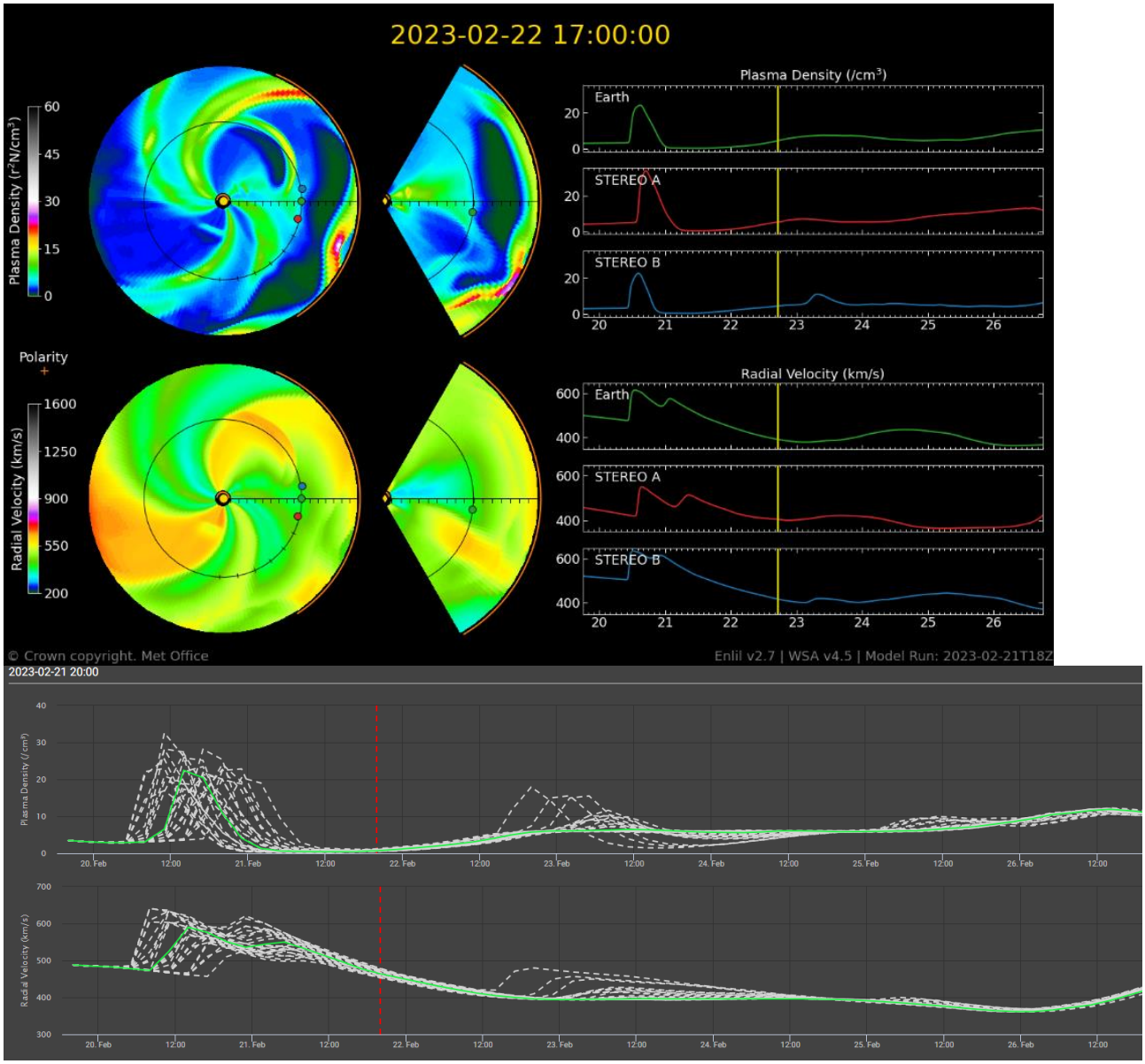
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
19.2320	Partial	Prominence near AR3217	SW limb	662 km/s	Probable miss	Some Enlil ensemble members suggest glance late 22 into 23 February.
21/1511	Partial	Probable filament eruption	NW limb	378 km/s	Probable miss (over Earth)	NW-heading shock inferred back to AIA171 high coronal activity, low confidence in source region especially. Visible in C2 and STEREO COR2 only, close-in fit.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: Met Office ENLIL including ensemble output showing arrival times of CMEs.



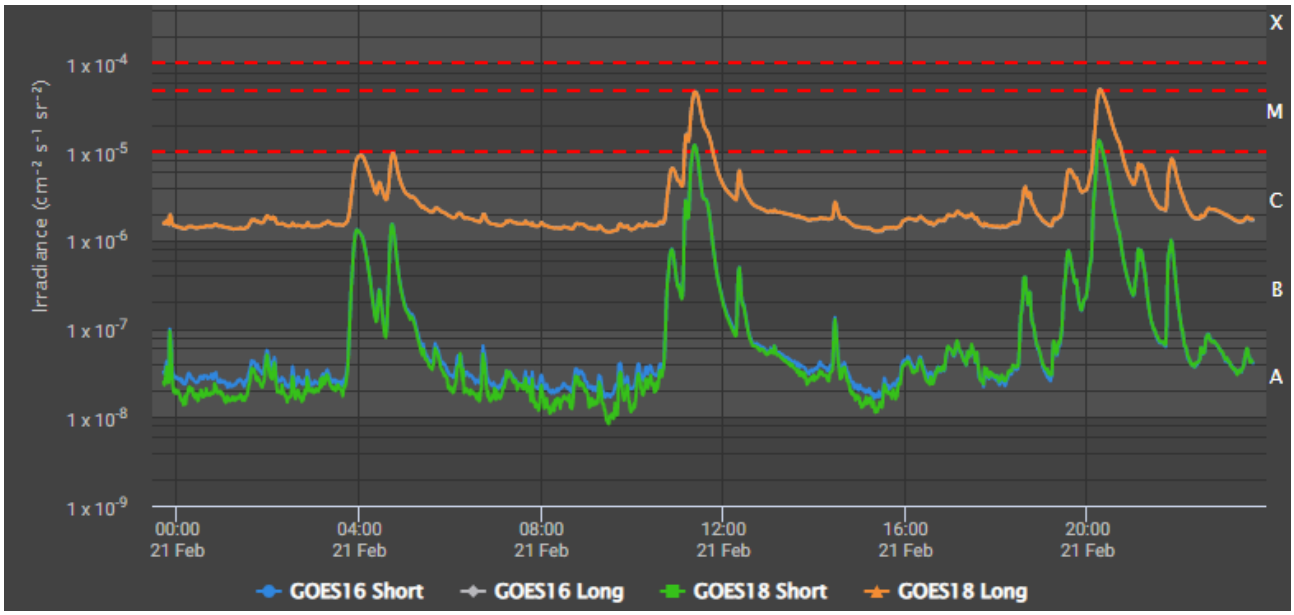
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Radio Blackouts - X-Ray Flares:
Further M-class X-ray flares are Likely in the four-day period, with a Slight Chance for High levels given any further X-class flares - the main risk being from AR3234 and perhaps still AR3229 in the northeast. Seven numbered sunspot regions are on the visible disc. Most are stable and unipolar. However of particular note in the northeast is AR3234 which continues to grow areally with further spot emergence, penumbral development and appears to have a delta spot. AR3229 in the northeast is also of note with development of the intermediate spots. AR3230 in the southeast has shown some further development of small trailing spots. The main regions should occupy the Earth-facing side through the next week, and barring development they should account for the bulk of the risk of significant flares. This is the posited rationale for only a slight decrease in risk with the departure of many of the western limb sunspot groups around midweek, which are for the most part unipolar or simple dipoles.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	60	60	50	50
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: X-ray flux at GEO as measured by GOES with two M-class flares observed in past 24 hours.



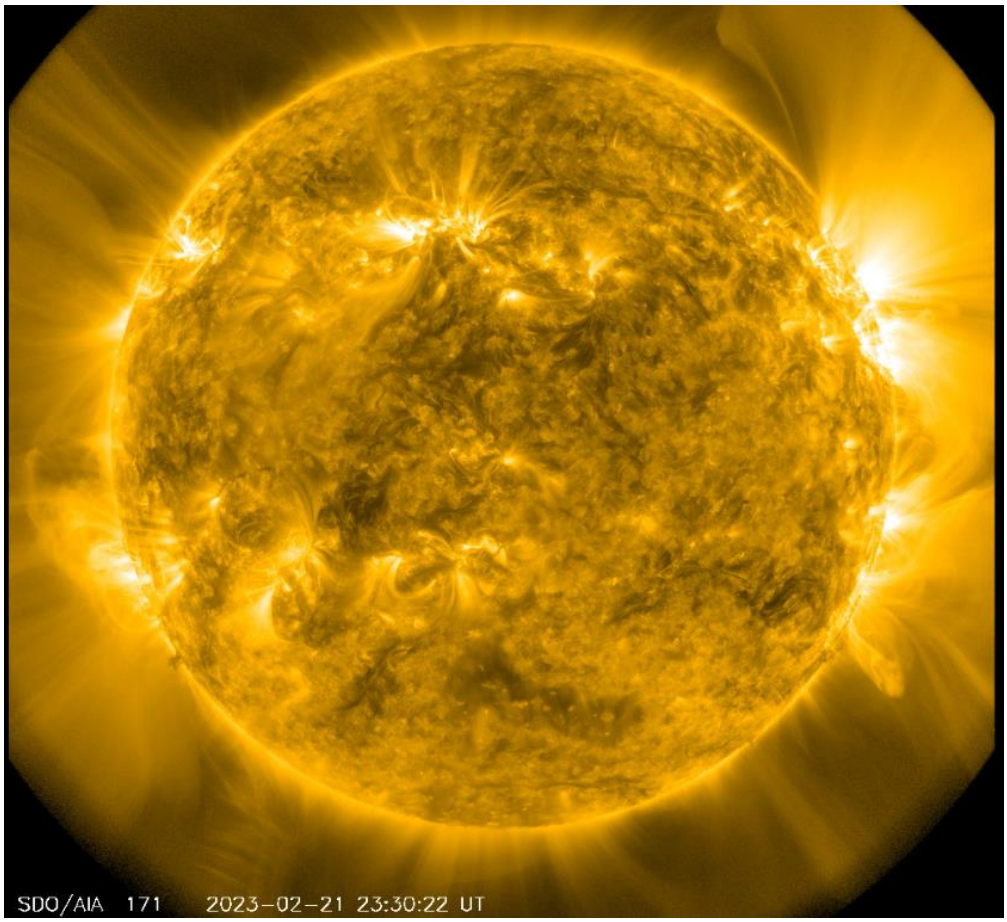
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at Background levels.
While there have been no notable enhancements to the high energy proton spectrum in the past UTC week, this is perhaps largely because the larger X-ray events have been limited to the eastern solar hemisphere. Ar3229 and AR3234's westward progress should offer a very gradually increasing Slight Chance of reaching S1 or above as they rotate into a more favourable position should they flare more energetically.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest SDO-aia 171 imagery giving an indication of the active regions on the visible disc.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed at GOES16 is currently showing a very slight day-on-day increase to oscillate between Moderate and Normal Background levels. Any more persistent increase in flux is now likely to be suppressed by geomagnetic activity arising from the fading 17 February CME at Earth. In terms of the forecast, there are now some signals that a high speed stream related to CH77 may have arrived at STEREO A (a day upwind in the Parker spiral), although the speed trace is erratic and has yet to settle, which makes gauging the intensity of CH77 difficult. It is still therefore considered relatively unlikely that CH77 should prove capable of Active electron fluence later this working week (UTC). With remaining transients now low confidence for affecting Earth at all, and with CH77 a persistent feature, confidence in MOSWOC REFM output is increasing, and this persists in maintaining below-Active fluence.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	10	20	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output over past 3 days.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.